GERMANIUM

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The Germanium, a grayish-white element, is a semiconductor, with electrical characteristics between those of a metal and an insulator. It is commercially available as a tetrachloride and a high-purity oxide and in the form of zone-refined metal ingots, single-crystal bars, castings, doped semiconductors, optical materials, optical blanks, and other specialty products. Germanium is used principally in fiber optics, infrared optics, and polymerization catalysts. Its excellent mechanical, optical, and electrical properties, as well as its moderate cost and availability in large physical shapes, make it attractive in many aerospace applications.

In 1998, the domestic germanium industry consisted of two zinc mining operations in Alaska and Tennessee, which supplied byproduct germanium concentrates to the export market, and three refineries in New York, Oklahoma, and Pennsylvania. In January 1998, Eagle-Picher Industries Inc., the largest domestic germanium producer, was bought by Granaria Holdings, a privately held investment company in the Netherlands, with holdings in Europe and the United States (Metal Bulletin, 1998c). The domestic refineries processed manufacturer's scrap, imported semirefined materials, and some old (postconsumer) scrap. Domestic refinery production, which amounted to slightly less than 40% of the world refinery production, was estimated to be valued at more than $37 million. Domestic refinery production and consumption for germanium are estimated by the U.S. Geological Survey (USGS) on the basis of discussions with domestic producers. Domestic refinery production of germanium was estimated to have increased moderately, but U.S. consumption remained at the 1997 level.

The USGS estimated domestic germanium reserves to be 450,000 kilograms (kg), equivalent to 16 years of domestic consumption at the 1998 rate; figures for worldwide reserves were not available. Worldwide, germanium resources are associated with zinc and lead-zinc-copper sulfide ores.

As a strategic and critical material, germanium was included in the National Defense Stockpile (NDS) in 1984, with an initial goal of 30,000 kg of germanium metal. In 1987, a new NDS goal of 146,000 kg was established; in 1991, this was adjusted downward to 68,198 kg. In 1995, the Defense Logistics Agency (DLA), which maintains the NDS, made plans to sell germanium at a rate of 4,000 kilograms per year (kg/yr) through 2005. This plan was increased to 6,000 kg/yr in 1997 and to 8,000 kg/yr in 1998. All the material offered was zone-refined polycrystalline germanium metal (U.S. Department of Defense, 1997). The amount designated for annual sales was a significant portion of the domestic and world market.

At the current level of disposal, the DLA price has become not only a good indicator of the market value of germanium, but also a factor in determining that value. Sales began the year at about $1,000 per kilogram, increased to a peak of $1,330 in October, and remained above $1,250 per kilogram at yearend (Mining Journal, 1999). Traders attributed some of the price increase to the DLA's switch in March from offering all remaining material available for the year at each monthly sale to limiting the sales to 250 kilograms per month (O'grady, 1998). This limitation would not allow the year's allotment to be sold on schedule. In an additional change, which would allow the disposal of the entire yearly allotment, the DLA began offering larger amounts of germanium on a long-term contract basis. The first offering of this kind was for 1,700 kg on September 3, 1998 (Metal Bulletin, 1998b). After selling 5,110 kg in 1998, the yearend inventory was 55,228 kg of germanium metal.

Production

In 1998, the USGS estimated domestic refinery production from primary and semirefined materials to be 22,000 kg, 10% more than that of 1997 and more than twice as much as that of 1993, 1994, or 1995. In 1998, Eagle-Picher's Quapaw, OK, Electro-Optic Materials Department remained the largest producer in the United States, producing germanium from reprocessed scrap, fly ash, germanium concentrates (typically containing 5% germanium or more), and semirefined germanium materials.

Cabot Corp., Revere, PA, and Atomergic Chemetals Corp., Plainview, NY, produced germanium from reprocessed scrap and semirefined foreign material. The zinc refinery at Clarksville, TN, which Savage Resources Ltd. acquired in 1994, continued to produce germanium-rich residues as a byproduct of processing zinc ores from its associated Elmwood-Gordonsville Mine. Savage Zinc Inc. has continued its established practice of shipping these residues to Union Minière's Electro-Optic Materials Business Unit in Belgium for germanium recovery and refining.

Consumption

In 1998, the USGS estimated that domestic consumption of germanium remained at the 1997 level of approximately 28,000 kg. The domestic use pattern was similar to the world use pattern, which was estimated to be fiber optics, 44%; polymerization catalysts, 22%; electrical/solar applications, 17%; infrared optics, 11%; and other uses (as phosphors, in metallurgy, and in chemotherapy), 6%. The major difference between the domestic and world patterns for consumption

involves polymerization catalysts. In the United States the greatest germanium demand is for fiber optics while in Japan most of the germanium used is for polymerization catalysts.

In the fiber optics sector, germanium was used as a dopant within the core of many optical fibers used by the telecommunications industry. Because germanium lenses and windows are transparent to infrared radiation, they can be used in infrared optical systems in the same ways ordinary glass lenses and windows are used in visible light optical systems. These optics were used principally for military guidance and weapon-sighting applications. Germanium glass was also used for nonmilitary surveillance and monitoring systems in various fields, such as satellite systems and fire alarms. The increase in consumption for nonmilitary systems did not match the decline in military consumption, accounting for the relative decrease noted for the infrared optical sector.

Prices

In 1995, for the first time, domestic producer prices for germanium metal and dioxide increased over the long-standing price levels established in late 1981 ($1,060 and $660 per kilogram, respectively). Throughout this 15-year period, producers significantly discounted prices because of competition from imported materials. In 1995 and 1996, producer prices for zone refined metal reportedly reached $1,375 and $2,000 per kilogram, respectively; and germanium dioxide producer prices rose to $880 and $1,300 per kilogram, respectively. In 1997, the producer prices fell back to $1,475 per kilogram for the metal and $950 per kilogram for the dioxide. In 1998, they increased again to $1,700 per kilogram for the metal and $1,100 per kilogram for the dioxide.

Free market prices for germanium dioxide, published by Metal Bulletin, started 1998 in the $675-to-$750 per kilogram range and ended the year in the $800-to-$840 per kilogram range. The price for Belgian-produced germanium dioxide, published by Metal Bulletin, remained at the 1997 level of $935 per kilogram throughout 1998. The fall in prices in 1997 was caused by a weakening of demand in the second half of the year and increased or new stockpile sales from Russia, Ukraine, and the United States. In 1998, prices increased in spite of an oversupply that resulted from slight decreases in world demand for optical fibers and polyethylene terephthalate (PET) and an increase in total supply owing to greater amounts of recycling and continued releases of germanium from national stockpiles in Russia, Ukraine, and the United States.

Foreign Trade

In 1998, the estimated germanium content of imports was approximately 7,400 kg compared with 16,300 kg in 1997. China, Taiwan, and Russia, in descending order of shipments, accounted for approximately 81% of U.S. germanium imports for 1998. (See table 1.) Imports directly attributable to China and countries of the former Soviet Union amounted to about 56% of the total. Trade reliance on large shipments from these countries is a fairly new pattern that began in 1993.

World Review

In 1998, world refinery production of primary germanium was estimated to be 56,000 kg, a decrease of about 12.5% from that of 1997, but 27,000 kg of germanium was recycled worldwide, an increase of 50%. Production was lower in Canada owing to smelter problems; (Metal Bulletin, 1998a) China, flooding; (Mining Journal, 1998) and Russia, political and economic uncertainty (Buchanan, 1998). Sales from the Russian and Ukrainian stockpiles totaled 7,000 kg. The world total market supply was about 95 metric tons (t) in 1998. World consumption was only 86 t, allowing 9 t of metal to increase producer stocks. World consumption for 1998 was nearly 10% lower than that in 1997.

Canada.— Management at Cominco Ltd.'s Kivcet lead zinc smelter in Trail, British Columbia, where germanium was a byproduct of the zinc operations, predicted that germanium production would reach normal levels during the second half of the year following various shut downs in the lead and zinc plants (Metal Bulletin, 1998a).

Japan.—Although the Japanese market for germanium has grown steadily during recent years, Japanese production has declined steadily since 1994, when production was 2.4 t. Production decreased to less than 0.5 t in 1998 from 1 t in 1997 (Roskill's Letter from Japan, 1999).

Current Research and Technology

After years of development work, the IBM Corporation has begun producing a silicon-germanium chip that will find use in portable devices, such as cellular phones. The new chip takes advantage of silicon's cost benefits and germanium's speed and could reduce power consumption by 50% in these devices. The current market for these chips is more than $500,000 and is expected to reach $1 billion within 5 years (Markoff, 1998).

Outlook

In 1998, as in 1997, germanium supplies exceeded demand for this specialty metal and its related products only because material was available from recycling and national stockpiles. Although consumption was sluggish in 1998, future germanium supply could tighten if increased demand from the fiber optics sector continues as has been projected (Talmedge, 1997) and if new or expanded sources of supply are not brought on-line in the near future. In fact, if present production levels are not increased when stockpiles are exhausted, then prices of refined germanium may be expected to rise again to elevated levels (Roskills Letter from Japan, 1997). If prices remain elevated, however, then competition from alternative materials will become an increasingly significant factor in germanium markets, and recycling will continue to grow (Metal Bulletin, 1997).

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[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
U.S. IMPORTS OF GERMANIUM, BY CLASS AND COUNTRY 1/ 2/

Class and country	1997 Gross weight (kilograms)	1997 Value	1998 Gross weight (kilograms)	1998 Value
Unwrought and waste and scrap:				
Belgium	10 r/	$67,200 r/	127	$284,000
China	3,420	5,240,000	2,720	2,730,000
Estonia	37	44,800	--	--
France	--	--	165	6,570
Germany	188 r/	214,000 r/	(3/)	1,850
Hong Kong	63	152,000	--	--
Israel	16 r/	28,200 r/	37	57,900
Korea, Republic of	100	25,000	--	--
Netherlands	58 r/	139,000 r/	--	--
Romania	--	--	6	3,980
Russia	8,100 r/	11,500,000 r/	1,330	1,390,000
Spain	500	601,000	500	604,000
Taiwan	846	67,700	1,990	131,000
Ukraine	2,000	3,180,000	130	107,000
United Kingdom	963 r/	1,230,000 r/	408	415,000
Total	16,300 r/	22,500,000 r/	7,420	5,730,000

r/ Revised.
1/ Data are rounded to three significant digits; may not adds to totals shown.
2/ Prior to this publication, data in this table also included wrought germanium.
3/ Less than 1/2 unit.

Source: Bureau of the Census.